Addendum

A Study to Address the Issue of Seafloor Stability and the Impact on Oil and Gas Infrastructure in the Gulf of Mexico
OCS Study MMS 2005-043

Responses to Comments/Study Review by the Louisiana Department of Natural Resources (Office of Coastal Restoration and Management) and Outside Technical Reviewer (Dr. Gary Zarillo, Florida Institute of Technology)

by Rob Nairn and Qimiao Lu, Baird & Associates

February, 2006

Introduction

Comments from the Louisiana Department of Natural Resources (LDNR) Office of Coastal Restoration and Management and Dr. Gary Zarillo at the Florida Institute of Technology were received after the publication of the Final Report noted above. This addendum provides a response to the valuable points raised in these two reviews.

Response to LDNR Comments

The points raised by LDNR in the letter from G.M. Duszynski dated December 8, 2005 are addressed individually below with the same numbering that they were presented in the above noted letter. The comments from LDNR are reproduced in italics followed by the response of the authors of the report.

1. A good description about the evolution of other channels and pits is made in Section 2.3 (page 49). However for the purpose of this study comparison of evolution (/migration) of channels with borrow pits in marine environment does not appear to be very relevant. The geometry of the channels as cited in section 2.3 (the Mobile Harbor Bar Channel and the Nile River Delta LNG Facility Dredged Channel) is different than those of borrow pits in Ship Shoal and Sandy Point and so is the hydrodynamics. The channels are open system whereas both these borrow pits are closed ones. Moreover these channels are regularly dredged. Obviously the forcing functions that govern the evolution/migration of channels are not entirely consistent with the forcing functions that control the evolution of borrow areas dredged in marine environment. Energy equations and regimes are very different. Has any such migration of a borrow pit under similar marine condition/analogues environment reported from Louisiana of Florida and have been studied or monitored?

1. As described in the report, the Mobile Bay Bar Channel and the Nile River Delta LNG Facility do in fact feature very similar hydrodynamic conditions and water depths to those of existing and proposed dredged pits along the Louisiana coast. LDNR suggest that the fact that the dredged channels we used as examples are "open" systems, and considering that they are regularly dredged means that they are different in their morphologic response characteristics. The fact the channels are open in these two examples really makes little or no difference to the hydrodynamic and resulting morphodynamic response because the channels either feature very weak flow along the channel (in the case of the Mobile Bay Bar Channel) or none at all (Nile River LNG Channel). The primary morphodynamic response of both these channels is due to cross-channel flow similar to what may be expected for a dredged pit. The fact the channels are dredged also does not significantly alter the pit margin response process that these examples were used to demonstrate. This is particularly true in the case of the Nile River LNG Channel which had only been dredged once (i.e. the initial capital dredging project). The LDNR letter asks if migration of borrow deposits was documented for similar marine conditions to those reported or studied in Louisiana or Florida. First, as we document in the report, the Delray, Florida pits feature very different sediment transport characteristics than the existing and proposed pits in Louisiana considered in the study (see also the answer to Question 3). Second, we maintain that the examples we selected are indeed representative of the types of processes expected for the Louisiana pits, and specifically the pit margin erosion effect.

2. The analogy with Tampa Bay Dredge Pit (Sec 2.3.2) and South Carolina Dredge Pit (Sec 2.3.4) would have been somewhat better because of similarity of environment but the lack of adequate data belie the purpose of quoting these examples.

2. The authors agree that the data were unfortunately limited for the Tampa Bay and South Carolina examples of dredged pits. However, these examples may serve to show that in areas of active sediment transport (which these are, in contrast to the Delray pits offshore Florida's southeast coast as explained in the report) side slopes do indeed become much flatter than the original post-dredge slopes, as suggested by our work and that of the physical models and field investigations reported in the SANDPIT study (van Rijn et al, 2005).

3. On Page 67 in 2nd paragraph the reason of the steep slope at Delray Beach Borrow area was given as little or no mobility. Does the author have any measurement of gross annual sand transport in Delray Beach? As mentioned what other pits "… around the US Coasts" have been investigated besides Delray Beach by the author, and with what result.

3. The authors have extensive experience with estimating sediment transport rates (and comparing these rates to measurements of one kind or another) around the US coasts and throughout the world. The authors did not have access to any direct measurements of sand transport at the Delray site, however, measurements of current speeds and estimates of wave conditions (validated against

measurements) were available. The key at the Delray site is that the pits are located in depths of water greater than 30 to 40 ft, where sand has low mobility under the given wave and current conditions. The approaches recommended in the SANDPIT study (van Rijn et al, 2005) were used to estimate sediment mobility at Delray along with the local measurements or estimates of waves and currents.

4. Page 84: All these data were collected by Louisiana Department of Natural Resources. Coastal Planning & Engineering Inc. were the consultant to do the job as directed. Please consider modifying the information on this page as well as on other places in the report too.

4. Acknowledgements for data sources are provided in Section 2.1.1 of the report. We acknowledged the organizations that provided the data to us directly. We apologize for not repeating these acknowledgements on all figures and for omitting LNDR's role in initiating, managing and funding the investigations to collect the data.

5. Different buffer width has been recommended for different setting. For sandy settings a 50 m buffer width has been recommended. In Louisiana it is a general practice of leaving 500 feet of buffer width between the edge of the borrow pit and oil & gas pipelines. In case of mud-capped borrow area a range of buffer width has been recommended and the reason given is the phenomenon of "… erosion beyond the edge of the pit…" This idea is pretty vague and the accuracy of measurement needs to be established.

5. The recommended buffers are minimum distances primarily based on morphologic response factors. Regarding the pit margin response process for muddy-capped pits, and need for much larger buffers than pits in sandy seafloor settings, extensive documentation and explanation of this process is presented in Section 3 of the report. To suggest this explanation is "vague" would imply the reader has not thoroughly read or understood the report. We would be pleased to address specific technical questions on this process. Nevertheless, the authors agree with LDNR that more data is required to improve our understanding of this process.

6. In connection with the above a very important and crucial observation has been made in paragraph 2 on page 84 relating to 1 to 2 feet of vertical erosion over a distance of 120 m. Based on this observation very important and very far reaching recommendations were made for buffer-width in mud-capped borrow area which is different from sandy settings. This makes the measurement of 1 to 2 feet very crucial and consequently this measurement has to be as accurate as possible. This raises following few questions about the accuracy of data collection in general:

a. What was the accuracy of the fathometer used?
b. Was the fathometer calibrated?
c. It seems that the tide correction was done on the basis of predicted tide. How much difference is expected?

d. *With what data the comparison was made? (Neither the post construction survey nor was the survey during May 2004 was conducted that far from the pit-edge).*

6. LDNR raises a very important question. The authors recognize the importance of the accuracy and datum consistency between the surveys and invested considerable effort in assuring themselves that the "1 to 2 ft" of erosion was indeed real and not an artifact of inaccuracy. In addition to this review, the authors considered the overall morphologic response around the pit and particularly the difference in response between areas that had been stripped and not dredged for sand and those areas that had not been stripped. In areas where sand was exposed through stripping but not dredged (i.e. essentially including a localized sandy pit setting) there was generally less than 1 ft to no erosion, as we would have expected. Another re-survey of the Holly Beach Dredge Pit is planned for February 2006 to provide additional data on the pit margin response in support of another project for MMS on "Examination of the Physical and Biological Implications of Using Buried Channel Deposits and Other Non-Topographic Offshore Features as Beach Nourishment Material".

7. Even if somehow it is accepted that pit margin eroded 1 to 2 feet vertically over a period of time then the most vital question would be that how this extremely slow process (unlike catastrophic phenomenon) of erosion will impact/damage the pipelines.

7. It is likely that the process of pit margin erosion generally proceeds as a slow morphodynamic adjustment. However, it is also possible that during extreme events, such as Hurricane Rita that passed directly over the Holly Beach Dredge Pit, the adjustment may be very rapid. Whether slow or rapid, exposure of oil and gas pipelines (let alone undermining) is unacceptable to MMS. The only advantage of a slow response is that mitigative measures such as placing rip rap over exposed or undermined pipelines could be implemented in time to avoid pipeline rupture.

8. It is stated on page 155, 1st paragraph that "… where the suspended sediment inputs from nearby rivers contribute to net sedimentation, pit margin erosion will be reduced or altogether eliminated…" Sandy Point borrow area is very near to the Mississippi River and there is no doubt that there will be sedimentation once a borrow pit is dredged in the vicinity. This is acknowledged in the study on page 156 in the last two sentences of the first (continuing) paragraph. But still recommendations (page 155, last paragraph) are made for buffer width of 100-150 and 200-300 m without considering this aspect which admittedly is very crucial.

8. Question 8 correctly states that background suspended sediment concentration, including the effect of discharge from nearby river mouths, must be considered in the analysis of the evolution of dredged pits. However, contrary to the statement in Question 8, the influence of this factor was indeed considered in the prediction of pit evolution for the Sandy Point Pit. However, there were no direct long-term

measurements of suspended sediment at the Sandy Point location and therefore the concentrations had to be estimated through a variety of parameters as explained in the report. The prediction could be improved with direct measurements of suspended sediment concentration at the site.

9. Please replace "do" by "due" on page 155 in last but one line.

9. I believe this typographical error was corrected in our Final Report.

10. In Appendix A, Section 2.3 Pipeline Survey and Mapping the report notes that the pipelines have to be covered by law and that any discovered span has to be immediately repaired and any exposed pipeline has to be immediately covered. According to section 49 of the Code of Federal Regulations, subsection 192.612, underwater inspection and reburial of pipelines in the Gulf of Mexico and its inlets, each operator shall conduct appropriate periodic underwater inspection of its pipelines in the Gulf of Mexico and its inlets in water less than 15 feet deep as measures from mean low water. If the pipelines are located in water deeper than 15 feet, as is the case at Sandy Point between isobaths 34 and 35 feet and Ship Shoal at isobath 15.6 feet, then inspections and coverage in the Gulf of Mexico as described in the report are not applicable. Thus it is noted in the study that oil & gas operators are not required to provide the MMS with as-built pipeline profiles only pipeline routes as required. We, at LDNR find it difficult to understand that oil & gas industries operators are not required to provide this information when the other agencies like LDNR are required to do so. As a condition of our lease for sand gravel and shell resources, in Sandy Point we had to provide significant survey information during and after construction to MMS. If the protection of our fragile oil and gas infrastructure were such a priority, it would seem that this information would be invaluable.

10. It may be appropriate that MMS address this question on the requirements of pipeline owners/operators to regularly survey pipelines for cover. However, it should be noted that even if regular surveys are not required, the MMS does from time to time, in response to extreme events, require through Notices to Lessees and Operators (NTLs) surveys of pipelines in all water depths. Surveys for a wide area were required subsequent to Hurricanes Rita and Katrina.

11. It would be appropriate for the study to note that there have been no reported incidents of pipeline failures/damages due to spanning or in areas adjacent to borrow areas. In 1994 National Academy of Sciences published an article entitled "Improving the Safety of Marine Pipelines" which examined data on pipelines failures based on information provided by the Minerals Management Service; the Department of Transportation's Office of Pipeline Safety; the US Coast Guard's National Response Center; the Texas General Land Office; the Louisiana Department of Natural Resources; and the State Lands Commission of California. The said study did not cite a single instance of either pipeline failure or damage. A current review of some of these data sources again showed no reference to pipeline failures/damage in areas adjacent to borrow areas.

11. Whether or not there have been damages reported due to spanning is not the concern of the report. The concern of the report is to provide recommendations on how to preserve pipeline cover requirements of MMS. Whether or not cover is required is another question that LDNR may wish to ask MMS directly.

12. In Section 2.5 and in Appendix-A, number of the issues regarding pipelines that are pertinent to the issue of the impact of seafloor stability on oil and gas infrastructure were enumerated but not addressed. As it had been indicated on earlier occasions that a serious review of the impact of seafloor stability on oil and gas infrastructure can not be undertaken without addressing these specific issues. The Appendix A does not address these questions nor does it give any additional information which is not very commonly available.

12. The purpose of the Pipeline Survey Report presented in Appendix A was to provide a context for the consideration of the possible impacts of dredged pits on oil and gas infrastructure. The initial scope of this specific investigation was broader in our original proposal. However, the scope was significantly reduced in order to make room in the budget for the Holly Beach Dredge Pit hydrographic survey as requested by LDNR and MMS. In hindsight, this was a very valuable trade off considering the information gained from the Holly Beach Dredge Pit on the evolution of dredged pits in muddy seafloor settings.

13. Page 9, 3rd paragraphs: - The survey referred was conducted in December 2003

13. It is noted that the Ship Shoal Block 88 hydrographic survey by C&C Technologies was completed in December 2003.

14. In the entire report the units are not consistent and made the reading very confusing especially in a study where the linear measurements are the important issues.

14. The following conversions should allow readers to translate most units presented in the report:
    a. 1 ft = 0.3048 m
    b. 1 yd^3 = 0.765 m^3

15. We concur with those involved with the SANDPIT study and the author's statement on

a. Page 41, 2nd paragraph that "… the models still require much improvement to be blindly reliable"

b. Page 176 "…that existing models and formulae do not produce accurate predictions of pit evolution."

In light of these recognitions, we echo our previous recommendation that MMS support a more robust study to adequately answer these questions prior to implementing more restrictive offset policies.

15. It is acknowledged that the SANDPIT study, as does the Baird report, urge caution in the interpretation of numerical model results of complex morphodynamic processes. Nevertheless, in the absence of more direct measurements of pit evolution, it is only prudent to use the tools and approaches presently available to the scientific and engineering community to attempt to evaluate pit margin erosion. The authors acknowledge that there is a need for more field data to improve these tools and approaches. As noted in response to Question 6, the MMS continues to support the improvement of the understanding of these complex processes through additional field data acquisition and analysis.

16. Though a minor point but worth noticing that the authors obviously took the help of several institutions/individuals in the preparation of this report but this has not been acknowledged anywhere the report.

16. The acknowledgement of all sources of data was made in Section 2 of the report.

17. The disclaimer makes an interesting reading. It notes that the report was prepared under contract between MMS and the author, then goes on to emphasize that the contents do not necessarily reflect the views and policies of the MMS. If this report is distributed by MMS and leads to changes in MMS policy then, it does specifically reflect the views and policies of MMS and this statement is misleading.

17. The disclaimer is a standard one that all authors of MMS studies are required to include in their reports.

Response to Comments by Dr. Gary Zarillo, Florida Institute of Technology

Dr. Zarillo provided comments throughout the report. Responses are provided to the three main areas of concern and questioning provided by Dr. Zarillo. Comments are in italics followed by responses.

The specific area of the report that may be weak and possibly subject to challenge is documentation of the modeling technology. The project employed two types of models, one empirical and the other numerical. The 1D empirical model adapted from the SANDPIT project is explained OK in terms of equations or assumptions, but a key reference on the model formulation (Liu and Zhang) is absent from the list of references. At a minimum the authors should include the cited 1992 reference and cite as many other projects as possible in which the Liu and Zhang empirical formulation has been used for practical predictions. Also the Authors should better justify the use of the tuning coefficients used in the Liu and Zhang formulation that were originally applied in the more tide dominated environments of the SANDPIT project.

The empirical equation for predicting siltation in a dredged channel (Equation 1 on page 91 of the report) was developed by Professor Liu in the 1960s. The equation was developed on the basis of wave dominated muddy seabed environments and was subsequently extended for combined wave and tide dominated conditions. The equation has been widely applied to predict the sedimentation in dredging channels in muddy coastal areas in China and throughout the world. The equation has been recommended in the Code of Hydrology for Sea Harbors (the official Chinese harbor design manual) and in van Rijn's (2005) book on "Principles of Sedimentation…" in which Prof. Liu's equation is the only equation recommended for estimating sedimentation of channels in muddy environments. Van Rijn (2005) incorrectly references Liu and Zhang (1992) as Jiaju and Jingchao (1992) – their first names. The correct reference is provided below. It should be also noted that Van Rijn (2005) was incorrectly cited as van Rijn (2004) in the published study report. Van Rijn (2005) is recognized as one of the leading references for sediment transport and sedimentation engineering, worldwide.

There are three coefficients in the Liu equations. The coefficients k_1 *and* k_2 were calibrated with laboratory data and field data and it is recommended that these default values be used in all applications unless site-specific calibration is undertaken. In the absence of site-specific data, the default or suggested values were used for the Holly Beach Dredge Pit simulation. The other key parameter is background concentration which represents the long-term averaged suspended sediment concentration in the vicinity of the pit or channel that is being infilled. Where possible, the background concentration should be estimated by long-term site measurements of suspended concentration. As this information is often unavailable (as was the case for the pits investigated in this study), Liu provided another equation to estimate background concentration based on site wave and tidal current conditions (Equation 3 on page 93 of the report). The second author of this report (Dr. Qimiao Lu) has applied this empirical equation to many coastal areas and has worked with Liu in the application of this equation to practical siltation assessments in China (see the reference list below). Also included are a variety of references for Liu. The correct citation for van Rijn (2005) is also provided.

Liu, Jiaju and Zhang, Jingchao (1992). Siltation Prediction for Navigation Channels and Harbour Basins on Muddy Beach. Parts I and II, China Ocean Engineering, Col. 6, No. 2 (p. 157-172) and No. 3 (p. 297-316).

Van Rijn, L.C. (2005). Principles of Sedimentation and Erosion Engineering in Rivers, Estuaries and Coastal Seas. Aqua Publications, The Netherlands. ISBN 90-800356-6-1.

Qimiao Lu (1993), On Predicting the Siltation of Dredged Channels in Shenmong Bay, *NHRI Technical Report.*

Qimiao Lu, Jinshan Zhang and Guohua Yu (1992), Estimation of the Sediment Siltation in the Outer Navigation Channel for 15-Ton Oil Dock in Xianmong Bay, *NHRI Technical Report.*

Qimiao Lu, Lei Geng and Jingchao Zhang (1991), Numerical Modeling and Empirical Analysis of the Sediment Siltation in Dredged Channels for the General Arrangements of Haicang Docks in Xianmong Bay, *NHRI Technical Report.*

Jiaju Liu, Guohua Yu, Zhaozi Shen, Qimiao Lu and Haiyong Tian (1991), Further Researches on the Availability of Port Building in Xiaomiaohong Waterway, *NHRI Technical Report.*

Jiaju Liu, Guohua Yu, Shudong Bao and Qimiao Lu (1989), Analysis on Sediment Siltation on Haikou New Port and Xiuying Port Induced by Reclamation in Haikou Bay, *NHRI Technical Repor.t*

Jiaju Liu, Guohua Yu, Zhaozi Shen, Qimiao Lu and Haiyong Tian (1988), Primary Researches on the Availability of Port Building in Xiaomiaohong Waterway, *NHRI Technical Report.*

Zhaosen Luo, Qimiao Lu and Sheng Huang (1987), Estimation Method and Mathematical Model for Predicting Siltation in Dredged Estuarine Channels, *Second International Conference on Coastal and Port Engineering in Developing Countries, Beijing, China*.

Liu, Jiaju, Computation on siltation in approach channels and port basins of silty mud coast, in *Code of Hydrology for Sea Harbour*, JTJ 213-98, (in Chinese).

Liu, Jiaju (2003), Study on Sediment in Sea Ports and Coast Protection, *International Conference on Estuaries and Coasts, Hangzhou, China*, p. 436 – 444.

Liu, Jiaju (1992), Study on sediment movement under wave action, *Proceedings of the Symposium on Fundamental Theory of Sediment Movement*, China, Vol.II(in Chinese).

Liu, Jiaju (1990), Prediction of Siltation in Harbor Basin and Dredging Channel for 100 DWT ship in Lianyue Harbour, *NHRI Technical Report.*

Liu, Jiaju (1987), Determination of sediment concentration under waves and tidal currents on silty mud beach, *Scientific Research of Water Conservancy and Water Transportation*, No.2 (in Chinese).

Liu, Jiaju (1966), The problem of sediment threshold under wave action, *Monographic Comment on water Conservancy and Water Transportation*, No.10 (in Chinese).

Liu, Jiaju (1963), Study on sediment surged up by wind waves in the shore area of Tianjin New Port, *The siltation research of Tianjin New Port*, No.1 (in Chinese).

The MISED numerical model is presented in a very cryptic way. MISED is apparently the Baird in house proprietary 3D environmental model. Only one citation is used to document this model (LU and Wai, 1998) Other than this citation and mention that MISED is "unconditionally stable and highly efficient" over a long time step there are few other details on MISED. At a minimum the Authors should cite other applications and include a brief appendix on the model formulation. This would not compromise the proprietary MISED model since it is most likely formulated on the standard primitive equations. Again if there is a challenge of the MMS buffers, the lack of documentation and validation of MISED and the empirical SANDPIT model in the report would be an issue.

MISED is a three-dimensional model for simulation of hydrodynamics and sediment transport in rivers, lakes, and coastal areas. The model was developed the second author of this report, Dr. Lu. The model is capable of simulating the transport of cohesive (using Lick's formulae) and non-cohesive sediment transport (using van Rijn's approach). The model uses a second-order finite element grid with an unconditionally stable numerical scheme. There are several successful MISED applications in North America, as listed below:

- Prediction of Hydrodynamics and sedimentation in Port Huron basin in the St. Clair River, Michigan;
- Assessment of hydrodynamics and river erosion (downcutting) in the Detroit River, Michigan;
- Flood assessment in the Lower Pike River, Michigan
- Modeling study on hydrodynamics and contaminant dispersion in St. Louis River Bay, Minnesota
- Assessment of the impact of a river protection structure on the flood in the Credit River, Ontario, Canada
- Modeling tide currents on Country Harbor, Halifax, Canada

Selected applications of MISED in other countries are:

- Tidal current modeling on Curtis Harbor, Australia
- Tidal current and sediment transport modeling in the Pearl River, China
- Tidal current and sediment transport modeling in Rusi Bay, China
- Tidal current and sediment transport modeling for Huang Hua Harbour in Bo Hai Bay, China

Below is a list of selected publications on the MISED model. The Lu and Wai (1998) paper explains the numerical approach for developing an unconditionally stable solution.

Wai, O.W.H, Jiang Y.W., and Qimiao Lu (2003), Large-Scale Finite Element Modeling and Parallel Computation of Sediment Transport in Coastal Areas, *in Advances in Coastal Modeling, edited by V.C. Lakhan, Elsevier Oceanography Series, pp237-266.*

Onyx W. H. Wai and Qimiao Lu (2000), An Efficient Parallel Model for Coastal Transport Process Simulation, *Advances in Water Resources, Elsevier, Vol. 23, pp. 747-764.*

Chen, Y., Wai, O., Y. S., Li and Lu, Q. (1999). Three-Dimensional Numerical Modeling of Cohesive Sediment Transport by Tidal Current in Pearl River Estuary. *International Journal of Sediment Research, Vol. 14(2). pg. 107-123.*

Onyx W.H. Wai and Qimiao Lu (1999), Gradient-Adaptive-Sigma (GAS) Grid for 3D Mass Transport Modeling, *Journal of Hydraulic Engineering, ASCE Vol. 125, No. 2, pp. 141-151.*

Qimiao Lu and Onyx W.H. Wai (1998), An Efficient Operator Splitting Scheme for Three-dimensional Hydrodynamic Computations, *International Journal of Numerical Methods in Fluid, 26, 771-789.*

Qimiao Lu (1997), 3D Numerical Modeling of Sediment Transport with a New Solution Adaptive Grid Technique, *in the Proceeding of XXVII IAHR Congress, ASCE, Vol. 5.*

Qimiao Lu and Onyx W.H. Wai (1996), An Efficient Splitting Method with FEM and FDM for 3-D Hydrodynamic Computations, *Second International Conference on Hydrodynamics, Hong Kong, Vol. 2, 697-702.*

MISED was apparently used in a model of the borrow pits that was schematic rather than conforming to the actual or proposed geometry. Since MISED seemingly has 3D capability and calculates both hydrodynamics and transport of conservative and non-conservative variables (sediment) why not use the full capability? There may be data and boundary limitations that required the use of somewhat generic pit geometry and collapsing of MISED to a 2D mode, but these reasons were not clearly stated. Again, model limitation are OK, but from the standpoint of potential challenges these limitation should be mentioned

The reviewer provides a good recommendation to apply the full 3D version of MISED to simulate pit evolution. Due to the availability of data as well as the limits of time and budget for the current project, the MISED application was limited to the simulation of pit evolution in a simple 2DV configuration. The specific reasons for taking this approach were:

- The available data were not sufficient to set up MISED model for existing or proposed pits. MISED requires detailed bathymetry, tide and suspended sediment information at open boundaries, bed sediment information in the model domain, and wave conditions within the model domain (wave data is required to calculate sediment re-suspension in MISED). Most of these data (and particularly the dynamic boundary conditions) were not available for the sites investigated;

- Pit evolution is a long-term morphological process. Long-term model simulation is required to describe the process. Long-term simulation requires a strategic approach to characterize model input data to avoid continuous simulations on short model time steps that are computationally prohibitive. Development of an input schematization strategy to this application was beyond the scope of this project;

- In mixed energy tide and wave environments, the model (whether it is a simple empirical model or a comprehensive 3D model) should not only account for sediment re-suspension during high frequency tidal components (and wind-waves) but also net sediment transport associated with low frequency tidal components. Generally, high frequency tides such as (M2, K1, O1) are the dominant tides in the Gulf of Mexico and the corresponding tidal currents speeds are large. Combined with wind-wave generated orbital velocities, the currents driven by high frequency tides are the main force keeping suspended sediment concentration at a certain level. The low frequency tides (such as monthly, seasonal, and even annual tidal constituents) are major contributors to net or residual sediment transport. Therefore, both high frequency and low frequency tides, and wind-waves must be included in the model simulation. This requires that the model be capable of predicting sufficiently detailed sediment re-suspension during tides and also be capable of simulating net sediment loads over the long-term period. A 1D empirical model may not account for the full complexity of these physical phenomena. Therefore, another reason that the MISED model was applied to simulate the pit evolution was to verify the results calculated with the 1D empirical model;

- In reality, the tidal current direction will rotate with time and will also be influenced by meteorological conditions (such as wind and pressure driven currents). However, the principles of sediment deposition in a pit for all current directions should be the same as that in one direction. Therefore, the MISED was applied to simulate pit evolution in a schematic case based on a 2D vertical model. The 2DV model results should account for the sediment deposition in a pit and the erosion of the pit margin reasonably well.

Baird will be applying a 3D version of MISED to simulate the evolution of the Holly Beach Dredge Pit in more detail as part of the ongoing project for MMS: "Examination of the Physical and Biological Implications of Using Buried Channel Deposits and Other Non-Topographic Offshore Features as Beach Nourishment Material". This study will include the collection of additional field data for input and testing of the 3D model.

A third area that might be of concern is that no attention is paid to role of storms in the analysis. As mentioned in the notes on the text, there is plenty of documentation of storm driven sedimentation. One might argue that most of the morphologic change is caused by episodic storms rather than the average conditions applied in the study. It might be good to include a couple of storm-based predictions in the project for comparison with predictions under average conditions.

The reviewer provides a valid criticism of the approach used in this report. In the 1D and 2DV estimates of pit evolution the influence of wind-wave generated re-suspension of sea bed sediments on background concentration (and therefore this contribution to infilling) is implicitly considered. However, given the water depths at the Holly Beach Dredge Pit site (8 m or more) and the non-cyclonic wave conditions (typically not greater than about 3 m), the contribution of waves to local transport through longshore currents, cross-shore currents and orbital velocities (both linear and non-linear) will be limited in most conditions. However, it is likely that during hurricane events, such as Hurricane Rita that passed directly over the Holly Beach Dredge Pit, waves will have a significant influence that cannot be ignored and may result in rapid adjustment of the pit form. Such direct hits by hurricanes are rare owing to the generally small scale and infrequent passage of hurricanes. Nevertheless, these effects will be investigated in more detail as part of the ongoing MMS study by Baird noted above.